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Method for governing the operation of a pneumatic impulse wrench and a power screw joint tightening tool system.

The invention relates to a method and a power tool system for screw joint tightening, where the power tool system comprises a pneumatic impulse wrench, and a programmable control unit is arranged to control the operation of the impulse wrench according to a predetermined tightening strategy and in response to instantaneous values of one or more tightening parameters by regulating during tightening the pressure air supply to the impulse wrench.

A problem concerned with pneumatically powered impulse wrenches is the difficulty to govern the tightening process accurately enough to ensure a correct and reliable pre-tensioning result. In a previously known impulse wrench system, described in U.S. Patent No. 5,366,026, the output shaft of an impulse wrench is provided with a torque transducer for detecting the torque magnitudes of the delivered torque impulses, and a control unit for calculating a torque based clamping force and for initiating power shut-off as a certain co-efficient representing an increasing clamping force has reached a certain value. There is also described a way to more safely arrive at the desired final clamping force by reducing the motive pressure air supply to the impulse wrench as the difference between a desired final clamping force and the actual calculated clamping force is smaller than a predetermined value.

This known tightening system has two weak points from the reliability point of view, namely that the actual instantaneous tightening parameter values, like the torque magnitude, are obtained from an easily disturbed torque transducer including a magnetostrictive output shaft portion and electric coils mounted in the impulse wrench housing. This arrangement is not only sensitive to external

disturbances resulting in a less reliable torque magnitude
detection but it is rather space demanding and adds in a
negative way to the outer dimensions of the impulse wrench.
The magnetostrictive output shaft comprises a number of
slots which weaken the shaft and call for an enlarged
output shaft diameter.

Although this prior art patent describes a process control
where the output torque of the impulse wrench is reduced as
the clamping force magnitude approaches the target value,
there is still a problem involved when tightening so called
hard joints, i.e. joints having a steep torque growth
characteristic. This is due to the fact that the very first
impulse delivered by the impulse wrench could turn out to
be powerful enough to cause a torque overshoot, i.e.
reaching a torque magnitude that is higher than the desired
final torque level. There is nothing described in this
document about how to deal with this problem.

In WO 02/083366 there is described a technique for
determining the installed torque based on signals delivered
by an angle sensing means mounted on the inertia drive
member of the impulse unit. This technique means that the
delivered torque is calculated from the angular movements
per time unit of the impulse unit, and that no torque
sensing means on the output shaft is required. However,
there is nothing described about how to control a screw
joint tightening process by changing the output of the
impulse wrench during the tightening process, for instance
how to avoid over-tightening at the very first delivered
torque impulse at hard joints.

In US 6,668,212 there is described a method for tightening
screw joints by means of a pneumatic torque delivering tool
wherein the accuracy of the tightening results is improved
by using calibration factors for power tool temperature,
power tool age etc. and by varying the air inlet pressure

to the power tool. This method is based on pre-production
calibration procedures where the calibration factors for
the actual screw joint and the different air pressure
levels to be used during tightening are determined. Since
this previous method does not use a power tool provided
with torque sensing means the output torque of the tool has
to be correlated to corresponding air pressure levels which
are listed in a table, and when applying the power tool on
a screw joint of a certain size the list tells the operator
what air pressure levels should be used to safely achieve a
desired final torque in the screw joint. Accordingly, this
known method is not universally applicable on different
screw joints but require a pre-production calibration
procedure on the actual screw joint. This is
disadvantageous in that it is complicated and time
consuming.

It is the object of the invention to provide a method for
governing a screw joint tightening process performed by a
pneumatic impulse wrench does not require any pre-
tightening calibration procedures and which is controlled
in such a way that overtightening of the screw joint is
safely avoided under all conditions, and a power tool
system for performing the method and including a pneumatic
impulse wrench which combines a simple and compact design
with a reliable parameter magnitude sensing and
ascertaining.

A preferred embodiment of the invention is described below
with reference to the accompanying drawing.

In the drawing
Fig. 1   illustrates a power tool system according to the
invention.
Fig. 2   shows an enlarged fractional view of the impulse
wrench shown in Fig. 1 and illustrates the angular movement
sensing device.

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The power tool system illustrated in Fig. 1 comprises a
pneumatic impulse wrench 10 including a motor 11 with a
rotor 12, an impulse unit 13 including an inertia drive
member 14 connected to the motor rotor 12, and an output
shaft 15. The impulse wrench 10 further comprises an
angular movement detecting device 16 which includes a disc
17 with a magnetised rim portion 18. The disc 17 is rigidly
affixed to and co-rotating with the inertia drive member
14, and a stationary sensing device 19 located
approximately to the magnetised rim portion 18 of the disc
17. The rim portion 18 is magnetised to provide a number of
magnetic poles equally distributed along its periphery, and
the sensing device 19 comprises sensor elements 120 carried
on a connection board 20 and activated by the magnetic
poles of the rim portion 18 to deliver electric signals in
response to the movement of the disc 17. The connector
board 20 is coupled to a circuit board 21 which carries a
number of electronic components (not shown) for treating
the signals delivered by the sensor elements 120 and
sending secondary signals to a stationary programmable
control unit 22 via a multi-core cable 24. Pressure air is
supplied to the impulse wrench via a hose 25 and a flow
regulating valve 26 which communicates with a pressure air
source and which is connected to the control unit 22 for
receiving operating signals. The flow regulating valve 26
is of the type that is able to adjust the air flow
magnitude successively in the range between zero and full
power flow as determined by the signals delivered by the
control unit 22.

The signals delivered by the movement detecting device 16
correspond to the rotational movement of the drive member
14 and are used for calculating not only the speed and
retardation of the drive member 14 but also the installed
torque, because with the knowledge of the total inertia of
the rotating parts, i.e. the drive member 14 and the

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connected motor rotor 12, the energy and hence the
installed torque magnitude of each delivered torque impulse
may be calculated. This method of torque calculation is
previously described per se in the above mentioned WO
02/083366.

In addition to the above described method of calculating
and determining the delivered torque and lapsed rotation
angle during each torque impulse it is also possible to
calculate the torque rate of the screw joint, i.e. the
torque growth per angle increment. This is accomplished
during a first couple of impulses delivered to the screw
joint, and when the torque rate is calculated an determined
it is possible to adapt the continued impulse application
to the screw joint in a very accurate way, without having
to rely on pre-tightening calibration procedures on the
actual screw joint.

This means that the method according to the invention is
universally applicable on all screw joints within a certain
size range. By this new method occurring deviations in
torque rate between different screw joints are
automatically compensated for, and occurring screw joint
faults like misalignments, cross threading, ripped-off
threads etc. are immediately detected as abnormal torque
growth characteristics.

In contrast to previously described methods for
accomplishing a screw joint tightening control at
pneumatically driven impulse tools the invention makes it
possible to control the tightening process via the inlet
air pressure and without having to perform any pre-
production rest runs to calibrate the torque output of the
actual power tool in relation to the supplied air pressure
and other factors like temperature, power tool age etc.
According to the invention the output torque as well as the
torque growth are determined  momentarily during tightening

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process, and the inlet air pressure is immediately adapted
to the actual joint conditions such that a desired
tightening result is ensured, no matter the characteristics
of the actual screw joint. The power tool just has to be
programmed with the desired target torque level and a
chosen strategy for varying the inlet air pressure during
the tightening process in response to the set target torque
level and the calculated torque growth. No pre-production
test runs on the actual screw joint have to be performed
for calculation purposes.

Based on this previously described torque determination
method the operation of the impulse wrench is governed by
controlling the pressure air supply to the impulse wrench
motor via the flow regulating valve 26. According to the
invention the pressure air supply is controlled such that a
reduced motor power and speed is obtained before and during
the very first one or two delivered torque impulse or
impulses, where a torque growth calculation is performed.
Thereafter a full power air pressure is supplied to the
impulse wrench motor. When reaching a certain torque
magnitude which preerably is a certain percentage of the
set target torque level, for instance 80% of the target
torque level, the air flow regulating valve 26 is
instructed by the control unit 22 to reduce the air supply
flow and hence the motive air pressure to a certain level
or a predetermined percentage of the full power flow, for
instance 80% of the full power flow, to thereby reduce the
rotation speed of the power tool 10 towards the end of the
tightening process and minimise the risk of overtightening
the screw joint due to the influence of inertia related
dynamic forces. As the set target torque level is reached
the flow regulating valve 26 is instructed to further
reduce the air supply flow so as to interrupt the
tightening process either by stopping the impulse wrench or
by maintaining the installed torque magnitude via a

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continued impulse delivery at a further decreased air
pressure and reduced torque magnitude in each impulse.